Name Key

Equilibrium Practice Test

1. Consider the reaction system, $CoO(s) + H_2(g) \rightleftharpoons Co(s) + H_2O(g)$.

   The equilibrium constant expression is

   a) $\dfrac{[CoO][H_2]}{[Co][H_2O]}$ b) $\dfrac{[Co][H_2O]}{[CoO][H_2]}$ c) $\dfrac{[Co][H_2O]}{[H_2]}$

   d) $\dfrac{[H_2]}{[H_2O]}$ e) $\dfrac{[H_2O]}{[H_2]}$

2. Given the equilibrium,

   $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, if this equilibrium is established by beginning with equal number of moles of SO_2 and O_2 in a 1.0 Liter bulb, then the following ***must*** be true at equilibrium:

   a) $[SO_2] = [SO_3]$ b) $2[SO_2] = 2[SO_3]$ c) $[SO_2] = [O_2]$

   d) $[SO_2] < [O_2]$ e) $[SO_2] > [O_2]$

   SO_2 reacts at double the rate, so less is remaining at equilibrium.

Questions 3 & 4 refer to the following:

At a given temperature, 0.300 mole NO, 0.200 mol Cl_2 and 0.500 mol NOCl were placed in a 25.0 Liter container. The following equilibrium is established: $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$

3. At equilibrium, 0.600 mol of NOCl was present. The number of ***moles*** of Cl_2 present at equilibrium is

   a) 0.050 b) 0.100 c) 0.150

   d) 0.200 e) 0.250

	NOCl	NO	Cl_2
I	.5	.3	.2
C	+.1	-.1	-.05
E	.6	.2	.15

per 25 L

4. The equilibrium constant, K_c, is:

   a) 4.45×10^{-4} b) 6.67×10^{-4} c) 0.111

   d) 0.167 e) 1500

$K_c = \dfrac{[.008]^2[.006]}{[.024]^2}$

$K_c = 0.000\overline{6}$

5. At 985°C, the equilibrium constant for the reaction,

   $$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

   is 1.63. What is the equilibrium constant for the reverse reaction?

   a) 1.63 b) 0.815 c) 2.66

   d) 0.613 e) 1.00

$K_{rev} = \dfrac{1}{K_{forward}} = \dfrac{1}{1.63} = .613$

equal moles of gas

6. What is the relationship between K_p and K_c for the reaction, $2ICl(g) \rightleftharpoons I_2(g) + Cl_2(g)$?

a) $K_p = K_c(RT)^{-1}$ b) $K_p = K_c(RT)$ c) $K_p = K_c(RT)^2$
d) $K_p = K_c$ e) $K_p = K_c(2RT)$

7. For the reaction $2NO_2(g) \rightleftharpoons N_2O_4(g)$, K_p at 25°C is 7.3, when all partial pressures are expressed in atmospheres. What is K_c for this reaction? [R=0.0821 $L \cdot atm \cdot mol^{-1} \cdot K^{-1}$]

a) 4270 b) 0.0119 c) 0.291
d) 179 e) 2.06

$K_p = K_c(RT)^{-1}$
$7.3 = K_c(0.0821 \times 298)^{-1}$
$K_c = 179$

8. 0.200 mol NO is placed in a one liter flask at 2273 K. After equilibrium is attained, 0.0863 mol N_2 and 0.0863 mol O_2 are present. What is K_c for this reaction?

$$2NO(g) \rightleftharpoons N_2(g) + O_2(g)$$

a) 9.92 b) 3.15 c) 0.0372
d) 39.7 e) 0.576

	NO	N_2	O_2
I	.2	0	0
C	-.1726	+.0863	+.0863
E	.0274	.0863	.0863

$$K_c = \frac{[.0863][.0863]}{[.0274]^2} = 9.92$$

9. $N_2O_4(g) \rightleftharpoons 2\,NO_2(g)$

At 25°C, 0.11 mole of N_2O_4 reacts to form 0.10 mol of N_2O_4 and 0.02 mole of NO_2. At 90°C, 0.11 mole of N_2O_4 forms 0.050 mole of N_2O_4 and 0.12 mole of NO_2. From these data we can conclude

a) N_2O_4 molecules react by a second order rate law.
b) N_2O_4 molecules react by a first order rate law.

Impossible to tell

~~c)~~ the reaction is exothermic.
~~d)~~ N_2O_4 molecules react faster at 25°C than at 90°C.
e) the equilibrium constant for the reaction above increases with an increase in temperature.

10. For the equilibrium system

$$H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g) \qquad \Delta H = -42 \text{ kJ/mol}$$ (exothermic)

K_c equals 0.62 at 1260 K. If 0.10 mole each of H_2O, CO, H_2 and CO_2 (each at 1260 K) were placed in a 1.0-Liter flask at 1260 K, when the system came to equilibrium…

	The temperature would	The mass of CO would
a)	decrease	increase
b)	decrease	decrease
c)	remain constant	increase
d)	increase	decrease
e)	increase	increase

$Q = \frac{[.10][.10]}{[.10][.10]} = 1$

$Q > K_c$ (will shift left)

11. For the reaction system,

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$$

the conditions that would favor maximum conversion of the reactants to products would be

a) high temperature and high pressure
b) high temperature, pressure unimportant
c) high temperature and low pressure
d) low temperature and high pressure
e) low temperature and low pressure

12. Solid HgO, liquid Hg, and gaseous O_2 are placed in a glass bulb and are allowed to reach equilibrium at a given temperature.

endothermic

$$2HgO(s) \rightleftharpoons 2Hg(l) + O_2(g) \qquad \Delta H = +43.4 \text{ kcal}$$

The mass of HgO in the bulb could be increased by

a) adding more Hg.
b) removing some O_2.
c) reducing the volume of the bulb.
d) increasing the temperature.
e) removing some Hg.

$K_c = [O_2]$ (heterogeneous)

Hg doesn't have a concentration in the gas phase.

13. Consider the following system at equilibrium:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + 92.94 \text{ kJ}$$ exo

Which of the following changes will shift the equilibrium to the right?

~~I.~~ increasing the temperature
II. decreasing the temperature
~~III.~~ increasing the volume
IV. decreasing the volume
V. removing some NH_3
~~VI.~~ adding some NH_3
~~VII.~~ removing some N_2
VIII. adding some N_2

a) I, IV, VI, VII
b) II, III, V, VIII
c) I, VI, VIII
d) I, III, V, VII
e) II, IV, V, VIII

14. Which of the following statements concerning equilibrium is not true?

a) A system that is disturbed from an equilibrium condition responds in a manner to restore equilibrium.
b) Equilibrium in molecular systems is dynamic, with two opposing processes balancing one another.
c) The value of the equilibrium constant for a given reaction mixture is the same regardless of the direction from which equilibrium is attained.
d) A system moves spontaneously toward a state of equilibrium.
e) The equilibrium constant is independent of temperature.

15–17. The following questions refer to the equilibrium shown here:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

15. What would happen to the system if oxygen were added?

~~a)~~ More ammonia would be produced.
~~b)~~ More oxygen would be produced.
c) The equilibrium would shift to the right.
d) The equilibrium would shift to the left.
e) Nothing would happen.

16. What would happen to the system if the pressure were decreased?

shifts right (more gas)

a) Nothing would happen.
b) More oxygen would be produced.
c) The water vapor would become liquid water.
d) The ammonia concentration would increase.
e) The NO concentration would increase.

17. For a certain reaction at 25.0°C, the value of K is 1.2×10^{-3}. At 50.0°C the value of K is 3.4×10^{-1}. This means that the reaction is

As T increases, K increases (shifts right)

a) exothermic.
b) endothermic.
c) never favorable.
d) More information is needed.
e) None of these (a-d)

Answers: 1E 2D 3C 4B 5D 6D 7D 8A 9E 10A 11D 12C 13E 14E 15C 16E 17B